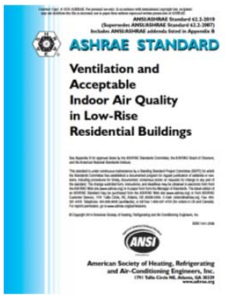
What We Will Talk About

- History and justification.
- Fundamentals of ASHRAE 62.2-2010.
  - Alternative compliance supplement.
  - Infiltration credit.
- Secondary requirements of 62.2-2010.
- Determining whole-building ventilation.
- Whole-building ventilation options.
- Measuring ventilation performance.
- Implementation for existing dwellings.
  - Background.
  - Implementation issues.
  - Installing whole-building ventilation.
- Fine tuning: Wisconsin impact study.

History and Justification

Standards 62-1989 and 62.2



A Brief History of Ventilation Standards

- Standard 62-1989 specified 15 CFM per person or 0.35 ACH for the building, whichever was greater.
  - Nothing for the materials in the space.
  - Standard was focused primarily on non-residential spaces.
- With Standard 119 – BTL.
- Also with Standard 136 – BTLa.

A Brief History of Ventilation Standards

- 15 CFM/person originated from smell tests in the 1930s (Yaglou et al. 1936) and more or less again in 1983 (Cain et al.; Fanger et al.).
  - How much air did we need to not be offended by each other's body odor?
  - Used bioeffluents (and 1930s hygiene) as a surrogate for IAQ.
  - Suggested might actually want 20 CFM/person.
    - Or 25 CFM for schools.
    - Or even 50% more for schools if the children hadn't bathed or changed their underwear in a week.

A Brief History of Ventilation Standards

- Standard 62.2
  - First time the ventilation rate took into account pollutants other than bioeffluents.
  - Halved the per person part (to 7.5 CFM).
  - Added a per floor area part to account for these other pollutants.
    - Want 3 CFM per 100 square feet.
    - Assume you get 2 CFM per 100 square feet from infiltration – need to deliver other 1 CFM per 100 square feet with mechanical ventilation.
    - Can get credit for more if you measure it with a blower door.

2011 DOE National Training Conference December 12-15, 2011 7

Wx and Ventilation

- Mission statement for DOE's low-income weatherization program:

"To reduce energy costs for low-income families, particularly for the elderly, people with disabilities, and children, by improving the energy efficiency of their homes while ensuring their health and safety."

2011 DOE National Training Conference December 12-15, 2011 8

Wx and Ventilation

- Most weatherization has used the BTL or BTLa for many years.
  - Some think it is a level that still provides enough air for combustion.
  - Some think it is enough for moisture control.
  - Some think it is enough for occupants.

NONE of these are true

2011 DOE National Training Conference December 12-15, 2011 9

Weatherization and Ventilation

- Misuse of 62-1989?
  - There has been an ongoing debate – "How tight is too tight".
  - There is a widely held view that the BTL is an abuse of 62-1989.
    - Not intended as a "stop sealing" but rather as a "how much ventilation" standard.
  - Often, the BTL seems similar to a cost-effective air sealing level, circumstantially.

Weatherization and Ventilation

- ~2005 – Wisconsin adopted 62.2.
  - Studies have shown.
    - Add ventilation in about ½ of homes.
    - Costs about $600 or so to install.
    - Impacts on humidity and carbon dioxide are beneficial.
      - Humidity lower by 4-5%.
      - Incidence of excessive carbon dioxide lower, especially during mild conditions.

More details later

WAP 11-06 Guidance

- Health & Safety committee convened Nov. 2010.
- One motivation was to clear up confusion from previous guidance.
- 8 Subcommittees.
- All items on the table, e.g.
  - Radon.
  - Appliances.
  - Ventilation.
  - Hazardous conditions (biological, chemical, etc.).

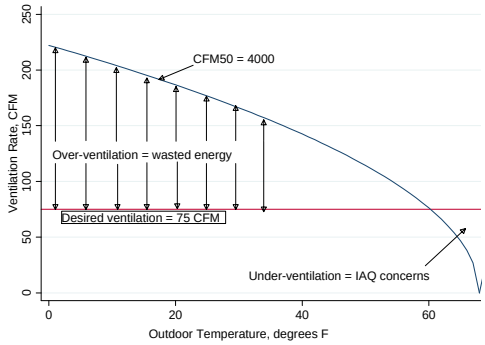
WAP 11-06 Guidance

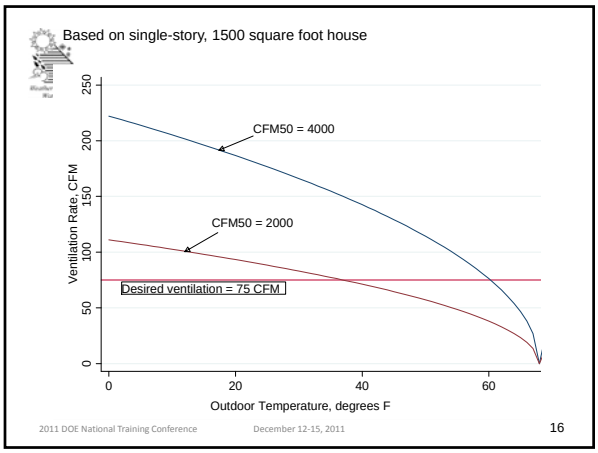
- Resulted in many new (or clarified) rules.
- For ventilation.
  - Ventilation Subcommittee recommended to the full committee to adopt 62.2, little to no dissent.
  - Full committee approved 62.2 adoption.
  - Went through internal review.
  - DOE decision made to require 62.2 starting next program year.

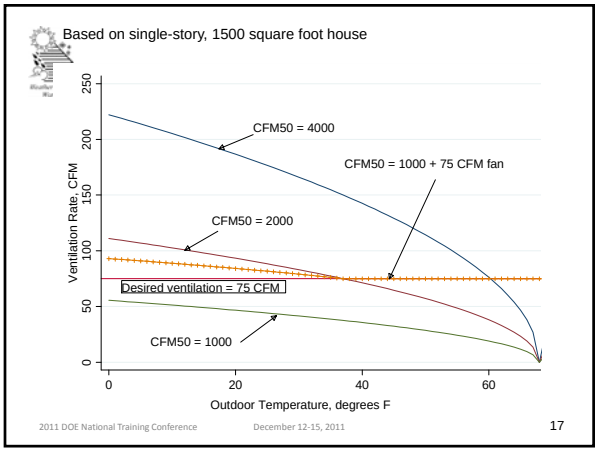
Ventilation vs. Infiltration

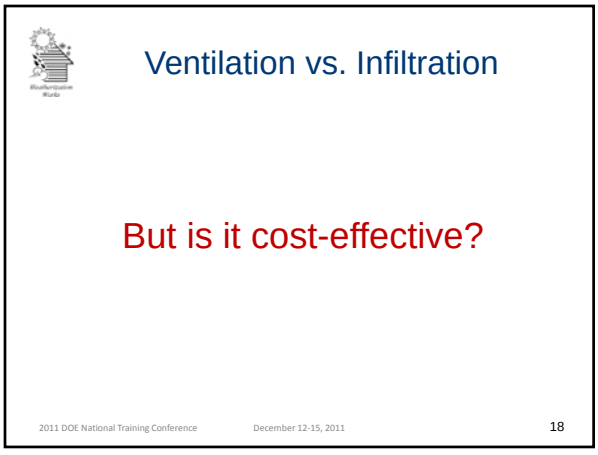
So why not just leave houses leaky, instead of spending money on both air sealing and then installing a fan?

Based on single-story, 1500 square foot house




Based on single-story, 1500 square foot house
CFM50 = 4000
CFM50 = 2000
Desired ventilation = 75 CFM
Ventilation Rate, CFM
0
50
100
150
200
250
0
20
40
60
Outdoor Temperature, degrees F
2011 DOE National Training Conference
December 12-15, 2011
16


Based on single-story, 1500 square foot house
CFM50 = 4000
CFM50 = 1000 + 75 CFM fan
CFM50 = 2000
Desired ventilation = 75 CFM
CFM50 = 1000
Ventilation Rate, CFM
0
50
100
150
200
250
0
20
40
60
Outdoor Temperature, degrees F
2011 DOE National Training Conference
December 12-15, 2011
17


Ventilation vs. Infiltration
But is it cost-effective?
2011 DOE National Training Conference
December 12-15, 2011
18

Ventilation vs. Infiltration

- Costs (of running fan).
  - Electricity for motor.
  - Conditioning of ventilation air.
- Savings (from air sealing).
  - Less conditioning of leakage air.

Ventilation vs. Infiltration

- Costs – example:
  - Assume 30 CFM fan running continuously.
  - Assume 11 watts.
  - Assume 10 cents/kWh, $1.00/therm, 90% furnace.
  - Electricity for motor $9.64
  - Gas for heating in Chicago $22.09
    $31.73 total, annual
  - Higher heating cost for propane or electric heat.

Ventilation vs. Infiltration

- Savings – example:
  - Assume starting Q50 = 3000 CFM_{50}
  - Final Q50 = 1680 CFM_{50}
  - Assume 6 people, 2000 square feet, 2-story
  - Leakage savings in Chicago $90.36
    (Subtract costs) $31.73
    Net savings $58.63 annual

Fundamentals of Standard ASHRAE 62.2

Three Fundamentals of Standard

- Local ventilation.
  - Vent moisture, etc. at the source.
- Whole-building ventilation.
  - Dilution air lower concentrations of pollutants.
- Source control.
  - Keep pollutants out of dwelling.
    - This topic is not part of this presentation.

Local Ventilation

- Exhaust the worst air in the dwelling as quickly as possible.
  - Bathrooms.
  - Kitchens.
  - Garages.
  - Crawlspaces.

ASHRAE 62.2 Requirements

- Local exhaust fans must be installed in bathrooms and kitchen.
  - Bathrooms (not half bathrooms)
    - 50 CFM on-demand, or
    - 20 CFM continuous.
  - Kitchen
    - 100 CFM on-demand*, or
    - 5 ACH, based on kitchen volume.
      - 12' x 14' x 7.5' kitchen requires 105 CFM.

***Vented range hood required if exhaust fan flow rate is less than 5 kitchen air changes per hour.**

Whole-Building Ventilation

- Dilution ventilation – bringing in enough outdoor fresh air to dilute the bad stuff already in the indoor air.
- Effectiveness depends on the quality of the outdoor air and the concentration of pollutants in the indoor air.

ASHRAE 62.2 Requirements

- Whole-building ventilation:
  - "A mechanical exhaust system, supply system, or combination thereof shall be installed for each dwelling unit to provide whole-building ventilation. . ."
  - Ventilation based on the table on next slide.
    - These CFM requirements are for whole-building continuous ventilation

Source: ASHRAE 62.2-2010, page 4

Whole-Building Requirements

Minimum Ventilation Air Requirements, CFM

Floor Area (ft^2)	Bedrooms				
	0 - 1	*2 - 3*	*4 - 5*	*6 - 7*	*>7*
<1500	30	45	60	75	90
1501 – 3000	45	60	75	90	105
3001 – 4500	60	75	90	105	120
4501 – 6000	75	90	105	120	135
6001 – 7500	90	105	120	135	150
>7500	105	120	135	150	165

2011 DOE National Training Conference

28

ASHRAE 62.2 Requirements

- Or use: $Q_{fan} = 0.01A_{floor} + 7.5(N_{bedroom} + 1)$
- Assumes two occupants in master bedroom and one in other bedrooms. For higher densities, increase by 7.5 CFM per occupant.
- Ventilation air must come directly from outdoors.
- Credit is allowed for envelope air leakage in existing homes, based on ASHRAE 136-1993*

A = conditioned space; "the part of the building that is capable of being thermally conditioned for the comfort of occupants." (ASHRAE 62.2, p.3)

**A Method of Determining Air Change Rates in Detached Dwellings*

29

ASHRAE 62.2 Requirements

- The whole-building ventilation requirements of the Standard may be satisfied by intermittent operation.
- In some cases, this is not a good alternative because:
  - May require high CFM fan flow rates.
  - Must provide automatic control.

2011 DOE National Training Conference December 12-15, 2011

30

Programmable Control

A control for whole-building fans

Air Flow adjustable from 40 to 100% of capacity in 16 increments for background ventilation rate.

Built-in Timer programmed at installation in multiples of 5 minutes for a 12 or 24 hour cycle.

Boost to full speed for 20 minutes by pressing button. Pressing again drops speed to background rate.

Airetrack™ by Tamarack

Alternative Compliance Supplement (Path) for Existing Dwellings

(Appendix A of 62.2-2010)

Alternative Compliance Supplement

- For existing dwellings only.
- Provides alternative method of meeting local exhaust requirements in kitchens and bathrooms:
  - That do not have any existing LOCAL fan, or
  - Where the LOCAL fans do not meet the CFM requirement.

Alternative Compliance Supplement

- In each room where local ventilation should be, determine deficit relative to required rate:
  - How much less than 50 CFM in bathrooms.
  - How much less than 100 CFM in kitchens.
- For each room with a deficit, reduce room's deficit by 20 CFM if that room has an operable window.

Alternative Compliance Supplement

- Add up deficits and divide by 4.
- Add the result (supplement) to the initial whole-building ventilation CFM.
  - This becomes the new whole-building ventilation minimum requirement.

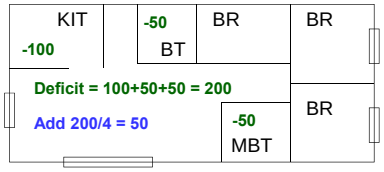
Calculated before infiltration credit is subtracted

Alternative Compliance Supplement

- For existing fans used, sound and ducting requirements of 62.2 are not applicable.
- Must measure flow if ratings don't exist or duct sizing can't be verified.
  - If only have rating at 0.10 in. IWC but not 0.25 in. IWC, can reduce rating at 0.10 in. IWC by 25%.

Alternative Compliance Supplement

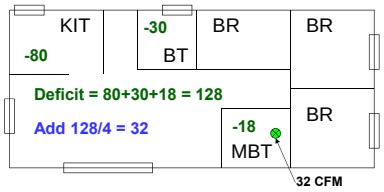
- Example #1: 3 BR, 1500 sq. ft. house



Whole-house requirement = 45 + 50 = 95 CFM

Alternative Compliance Supplement

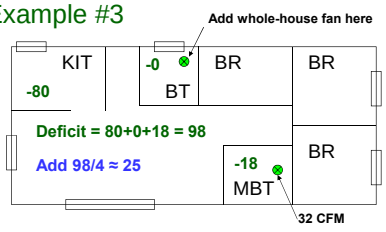
- Example #2: 3 BR, 1500 sq. ft. house



Whole-house requirement = 45 + 32 = 77 CFM

Alternative Compliance Supplement

- Example #3



Whole-house requirement = 45 + 25 = 70 CFM

Infiltration Credit for Existing Dwellings

Infiltration Credit

- Infiltration credit calculation for dwellings "built prior to the application of this standard".[1] This means existing dwellings.

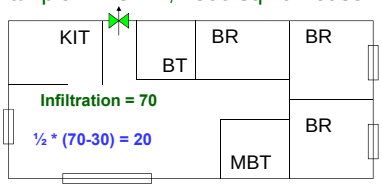
If:
Natural Infiltration > 2A/100
Then:
Infiltration credit = 0.5 (Natural Infiltration – 2A/100)

A = occupiable floor area in ft^2

[1] ASHRAE 62.2 - 2010, page 4, for whole-building ventilation

Infiltration Credit

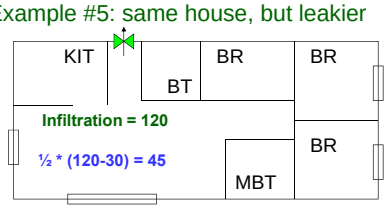
- Example #4: 3 BR, 1500 sq. ft. house



Whole-building requirement = 45 - 20 = 25 CFM

Infiltration Credit

- Example #5: same house, but leakier



Whole-house requirement = 45 - 45 = 0 CFM

Determining Whole-Building Ventilation

Example

	CFM
Initial mechanical airflow	= 30
Alt. compliance supplement	= +15
Infiltration credit	= - 10
Whole-Building Ventilation	= 35

Some Secondary Requirements of Standard 62.2

Some Secondary Requirements

- Must prevent migration of contaminates from attached garages to the adjoining occupiable space.
- Labeling and instructions to occupant.
- Vent clothes dryer to outdoors.
- Air inlets at least 10' from sources of contaminants.
- Sound ratings for installed fans.
- Duct requirements (R-8 if outside of envelope).

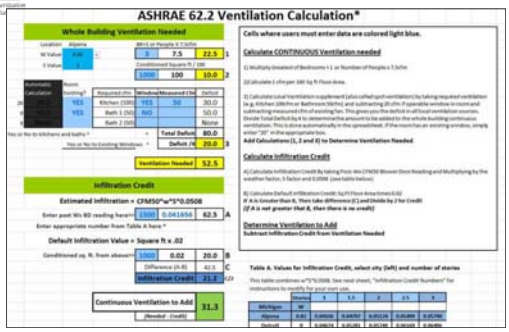
Not good!

Determining Whole-Building Ventilation

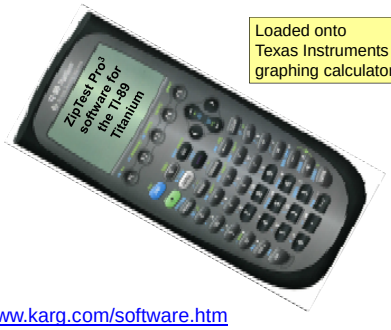
Methods for Sizing W-B Ventilation

- The whole-building ventilation is complicated to size for an existing house because of the infiltration credit. Existing methods of sizing include:
  - Manual calculation forms.
  - DOE Standard Curricula spreadsheet.
  - ZipTest Pro^3 for the Texas Instruments TI-89 calculator (R.J. Karg Associates).
  - ResVent 62.2 for the iPhone, iPad, and iPod touch (R.J. Karg Associates).
  - TECTITE software (The Energy Conservatory).

Calculate with Spreadsheet



Calculate with ZipTest Pro^3



Loaded onto Texas Instruments TI-89 graphing calculator

www.karg.com/software.htm

Calculate with ResVent 62.2

For iPhone and iPad. Must purchase from Apple app store

www.karg.com/resvent622.htm

52

Whole-Building Ventilation Options

Ventilation System Types

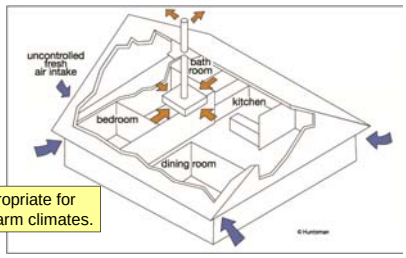
- System types:
  - Exhaust-only.
    - Separate exhaust fan(s).
    - Ducted in-line fan.
  - Supply-only.
  - Balanced system.
    - HRV (sensible heat recovery).
    - ERV (sensible and latent heat recovery).

Exhaust-Only Ventilation

- Exhausting unit(s) only, no supply ventilation.
  - Exhaust fan serving one exhaust point.
  - In-line fan unit serving one or more exhaust points.
  - Creates negative pressure in building.
    - Pulls pollutants from garage, etc.
    - Backdrafting potential.
  - Source of supply air?

2011 DOE National Training Conference December 12-15, 2011 55

Exhaust-Only



Not appropriate for some warm climates.

Source: "Proper Design of HVAC Systems for Spray Foam Homes", April 2011, by Doug Garrett for Huntsman Corporation.
Used with permission of Huntsman Corporation. 56

Panasonic WhisperGreen

-Speed-compensated for static pressure
- Constant run CFM from 30 to 70, switch to 80 CFM max.

57

Bathroom or Hall Exhaust Fans

Photos courtesy of Wisconsin Weatherization Program

58

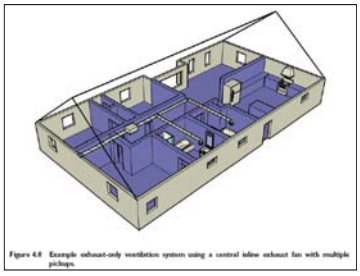
Kitchen Exhaust Fans

100 CFM, or
5 ACH of kitchen volume.

Venmar S1311LS range hood with 40 CFM background & 75, 160, and 270 CFM on-demand speeds.

59

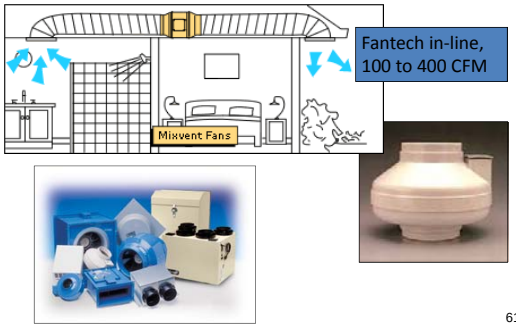
Exhaust-Only, Inline



Source: 62.2 User's Manual ©2006 ASHRAE

60

Fantech Inline Exhaust Fans



61

Inline Exhaust Fans

Photos courtesy of Wisconsin Weatherization Program

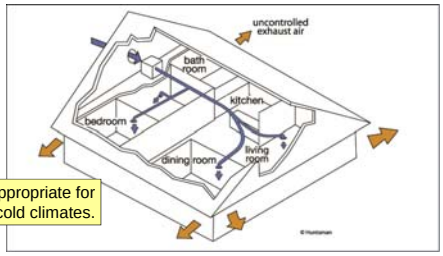
62

Supply-Only Ventilation

- Supply units only, no exhaust ventilation.
  - Supply fan serving one supply point.
  - In-line fan unit serving one or more supply points.
  - Creates positive pressure in building.
  - Not appropriate for cold climates.

63

Supply-Only Ventilation



Not appropriate for cold climates.

Source: "Proper Design of HVAC Systems for Spray Foam Homes", April 2011, by Doug Garrett for Huntsman Corporation.
Used with permission of Huntsman Corporation.

64

Supply Ventilation to Furnace Return Air

- Ducts must be tight (or they can bring in bad air).
- Must have good motorized damper.
- Must be controlled to run even if no heat is needed.
- Furnace fan energy use can be high.
- Intake must be kept clean of yard debris and other outdoor stuff.

2011 DOE National Training Conference December 12-15, 2011

65

Supply Ventilation to Furnace Return Air

Photos: P. Francisco

66

Terminations Gone Wrong

Don't do this!

Photos: P. Francisco

67

Terminations Gone Wrong

Don't do this!

Photos: P. Francisco

68

Results of Bad Terminations

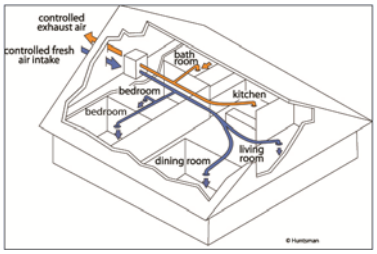
Different attics

69

Balanced Ventilation

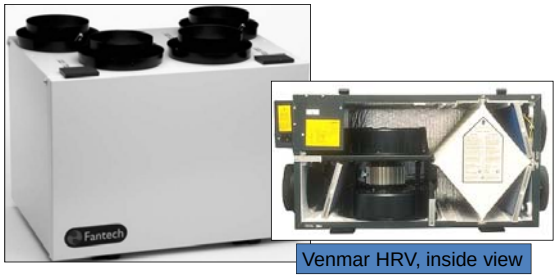
- Exhaust and supply ventilation are approximately equal CFM.
  - Heat Recovery Ventilator (HRV)
    - Unit transfers sensible heat only with no humidity transfer.
  - Energy Recovery Ventilator (ERV)
    - Unit transfers sensible and humidity.

Balanced System



Source: "Proper Design of HVAC Systems for Spray Foam Homes", April 2011, by Doug Garrett for Huntsman Corporation.
Used with permission of Huntsman Corporation.

Heat Recovery Ventilators (HRV)



Venmar HRV, inside view

HRV & ERV aren't Practical When:

- Energy is cheap.
- House is very leaky.
- There is no place for ducts.

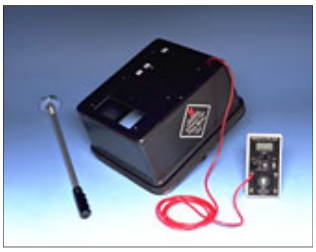
Whole-Building Ventilation Options Comparison

Option	Pressure	Advantages	Disadvantages
Exhaust only	Negative	Simple, low-cost installation.	No energy recovery. Location of supply air uncertain. Distribution uncertain.
Supply only	Positive	Simple, low-cost installation. Distribution control.	No energy recovery.
Balanced HRV	Neutral	Energy recovery. Lower operating cost. Good air in/out control. Good distribution.	High cost of installation. Difficult to install in existing dwellings.
Balanced ERV	Neutral	Energy recovery. Lower operating cost. Good air in/out control. Good distribution. Humidity control.	High cost of installation. Difficult to install in existing dwellings.

Measuring Ventilation Performance

Exhaust Fan Flow Meter

Measurement range from 10 to 124 CFM (1 to 8 Pascals)



Exhaust fan flow meter use

Exhaust Fan Flow Meter Chart

Meter Pressure (Pa)	Flow (CFM) E1	E2	E3	Meter Pressure (Pa)	Flow (CFM) E1	E2	E3
0.6	34	16	8	4.4	92	43	21
0.8	39	19	9	4.6	94	44	22
1.0	44	21	10	4.8	96	45	22
1.2	48	23	11	5.0	98	46	23
1.4	52	25	12	5.2	100	47	23
1.6	55	26	13	5.4	102	48	23
1.8	59	28	14	5.6	103	49	24
2.0	62	29	14	5.8	105	50	24
2.2	65	31	15	6.0	107	51	25
2.4	68	32	16	6.2	109	52	25
2.6	71	33	16	6.4	111	52	25
2.8	73	35	17	6.6	112	53	26
3.0	76	36	17	6.8	114	54	26
3.2	78	37	18	7.0	116	55	27
3.4	81	38	18	7.2	117	56	27
3.6	83	39	19	7.4	119	56	27
3.8	85	40	20	7.6	121	57	28
4.0	87	41	20	7.8	122	58	28
4.2	90	42	21	8.0	124	59	28

Or, measure directly with the DG-700

79

Implementation for Existing Dwellings

2011 DOE National Training Conference December 12-15, 2011 80

WI's Experience w/ 62.2

- Why WI opted to ventilate home.
- Why WI moved to 62.2.
  - 2004 Pilot.
- The link between ventilation & combustion.
  - Standard testing requirements.
- Ventilation Implementation issues.
  - Can you make it work in the field?
- Fine tuning the procedures.

2011 Conference December 12-15, 2011 81

Implementation

- Putting the issues on the table.
  - Implementation requirements.
  - How test data and information shapes decision making.
  - Challenges that gets solved by:
    - Changes to standards.
    - Administrative requirements.
    - Time and experience.

Background

Changing Housing Stock

- Houses smaller, tighter.
  - Many more 1960-1970's ranch style units coming into the program.
    - Don't need much insulation.
    - Mechanical have usually been changed out or we will.
    - Issues are often health & safety:
      - Air quality.
      - Moisture management.
      - CO/attached garages.
- Driven by service territory (housing stock).
- Building Tightness Levels.
  - Hit or miss solutions.

Ventilation: "Let's find a tool!"

- 2004-2005 (July 2004-June 2005).
  - BTLa (based on 62-1989).
    - Large fans, continuous ventilation.
    - Learned many lessons.
  - Implemented in July.
    - back to the drawing board in August.

2011 DOE National Training Conference December 12-15, 2011 85

62.2-2004 Pilot: Whole-building Ventilation Rates

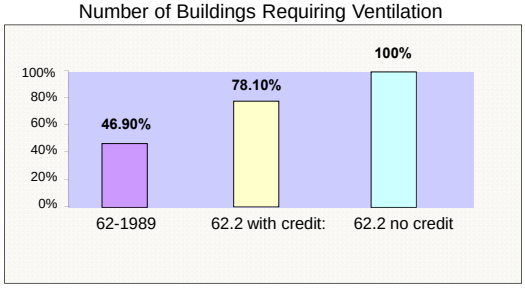
- Information collected on exhaust flow rates.
  - Existing equipment .
  - Added or replacement equipment.
  - Type of combustion systems.
- Blower door results.
- Calculated pressure differences.

2011 DOE National Training Conference December 12-15, 2011 86

62.2-2004 Pilot

Whole-Building Ventilation Incidence Rates

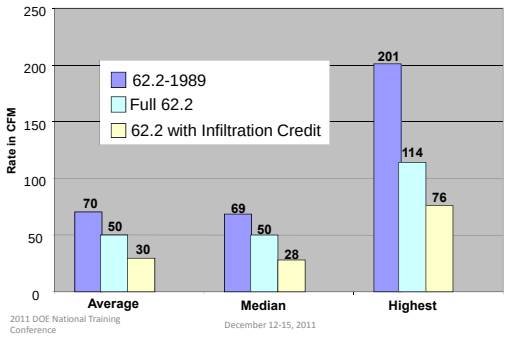
Number of Buildings Requiring Ventilation



2011 DOE National Training Conference December 12-15, 2011 87

62.2-2004 Pilot

Whole-Building Ventilation Rates



62.2-2004 Pilot

Projected Cost and Occurrence

- Expected to:
  - Install ventilation in 75-80% of units.
  - Invest $525 in equipment.
    - Fan & Controls.
  - Install an average of 30 CFM of continuous ventilation.
- Planned follow-up study for 2006.
  - Compare to expectation.
  - Fine tune the product.

62.2-2004 Pilot

Depressurization Testing

- Negative pressure not significant in stick built units at final.
  - Gives us good information about the building.
    - Most of the problems are fixable.
  - Verifies the safety at the close of work.
- Appears to be an issue with manufactured housing.
  - Newer mobile homes suck big time.
- More later…

WI's Standard Diagnostic Testing

- Blower door tests.
  - As is, pre-test, post-test, Zone diagnostics, as needed.
- Worst-case draft and spillage tests.
- Depressurization limit tests.
  - Exhaust appliance measurements/estimates.
- Ventilation.
  - 62.2 vent calculations.
  - Existing actual/estimate.
- Gas range CO testing.

62.2-2004 Pilot

Information Collected

- Exhaust flow rates.
  - Existing equipment.
  - Added or replacement equipment.
  - Type of combustion systems.
- Blower door results.
- Calculated pressure differences.

62.2-2004 Pilot

Housing Stock Drives Impact

- 62 Units were included in the study.
  - Only 3 units were depressurized to limits above allowable levels.
    - The existing exhaust appliances in these 3 units had flow rates that would cause the depressurization levels, not ventilation requirements that were added to these units.
    - Anecdotal: these results are reflective of actual practice.
      - There will always be some problem buildings that need special attention.

62.2-2004 Pilot

Conclusions

- Requiring ventilation helps to provide acceptable indoor air quality in homes.
- Switching to the ASHRAE 62.2 standard to determine ventilation lowers the possible impact on depressurization.
- Assessments on existing equipment versus adding equipment can be done sooner in the weatherization process to smooth production.

Implementation Issues

Implementing Ventilation

62.2: Prescriptive Standard It doesn't tell you how to do it!

- It gives you definitions
  - It doesn't give you interpretation.
- Basement in or out?
- It gives you the formulas and options
  - It doesn't provide easy to use tools for retrofit applications.
- It tells you what your end state needs to be
  - It doesn't tell you how to integrate into your work flow.

Implementing Ventilation

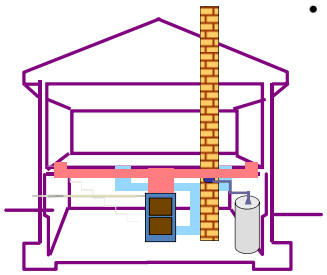
How Big Is the Building?

Habitable Space: Building space intended for continuous human occupancy…generally living, sleeping, dining, and cooking. Not bathrooms, toilets, hallways, storage areas, closets, or utility rooms.

Occupiable Space: Any enclosed space inside the pressure boundary and intended for human activities, but not limited to all habitable spaces toilets, closets, halls, storage and utility areas, and laundry areas.

Implementing Ventilation

How Big Is the Building?



- WI's Position:
  - If you'd open the basement door to get a CFM_{50},
  - If the basement is finished or living space,
    - **the basement is in.**

Implementing Ventilation

Key Interest Groups

- Trainers.
- Building occupants & owners.
- Auditor/inspectors.
- Crews/contractors.
- Local program management.
- State quality assurance staff.
- Local and state program administrators.

Implementing Ventilation

Implementation Hurdles

- New protocols & forms
  - Field testing.
  - Training & Implementation.
  - Quality assurance issues:
    - Error tolerance.
    - How do you measure success?
- Management comfort with protocols & goals.

Implementing Ventilation

Don't Underestimate Work-Flow Issues

- Who does what tests when?
- The numbers change when you're working on the building.
  - Depressurization of CAZ.
  - Blower door CFM50 numbers.
  - CFM of exhaust ventilation required.

Implementing Ventilation

Work Flow Issues (continued)

- When do you install whole-building ventilation?
  - What if the numbers change?
    - Start out needing 20 CFM, end up needing 70.
    - New controllers are very helpful.
- Do you need to add make-up air?
  - How and where?
  - Current models are not very helpful.
    - Best case scenario is good end-state planning.

Implementing Ventilation

Staggered Implementation

- Assessed our training capacity.
  - Built curriculum pieces.
  - Determined how many sessions were required for statewide implementation.
- Allowed grantees to signup for their training and implementation timetable.
  - Implementation required the day after training.
- Trained August through December.

Implementing Ventilation

Lessons Learned

- Local agencies loved staggered process
  - QA monitors did not love it—what? when?
- Training covered basic calculations and field planning.
  - Primarily inspection staff.
  - Dialogue on work flow.
    - Give weatherization professionals and the tools and they will figure out both the problems and the solutions.

Implementing Ventilation

Training Lessons

- Needed additional training in ventilation systems.
  - Installation options.
  - Target: inspectors, installers, subcontractors.
- Needed “Why Ventilate” training for staff and customers.
  - Staff need to believe in ‘why’ to sell customers on ‘why’.

Installing Whole-Building Ventilation

Installing Ventilation
What and Where?

- What type of installation?
  - Exhaust-only ventilation - most common option:
    - 58% of 1-4 unit buildings[1] get ventilation
      - 99% of those installations are exhaust only.
      - 1% exhaust with passive make-up air/ 0 HRV/ERV.
- Where will the fan be located?
  - In the attic close to the hatch? In the basement? In the bathroom?
- Where will the controls be installed?
  - Driven by the type of installation:
    - Near the fan? Remote from the fan?

Installation Issues

Production Decisions
When and Who?

- When is the whole-building ventilation rate determined?
  - Building's natural ventilation rate will changed based on air sealing.
    - If the building needs ventilation prior to Weatherization it will need ventilation post-weatherization.
- When in the WX process is the fan installed?
  - Before, during, or after weatherization?
- Who installs the fan?
  - What can crews or contractors legally do without trades?
    - Are they able to install the fan with an electrician hooking up the power or signing off on the installation?
    - Ducting to the outside?
- Who makes the final adjustment of fan airflow?
  - Crew, electrician, or final inspector?
    - Trust only trained technicians.

Installing Ventilation

Control Strategy

- Setting flow rates
  - Continuous at a low rate 20 CFM 24/7.
  - Intermittent at a high rate 60CFM 20 min. every hour.
  - 'Boost' option for bathroom to serve as local exhaust and to meet whole-building requirement for 62.2.

Installing Ventilation

Ensuring Flow Rates

- Performance Testing.
  - Measuring flow rates.
- Maintenance of systems.
  - Changing filters.
  - Cleaning grilles.
- Ducting methods.
  - Size and type of material.
  - Connections and sealing.

Sizing Considerations

Things to Avoid

- Do NOT oversize exhaust.
  - Adding more exhaust when existing could serve purpose of meeting required 62.2.
  - Sizing exhaust carefully—bigger is not better.
- Exercise caution in tight dwellings.
  - Newer mobile homes can be very tight.
    - Less than 900 CFM_{50}.
    - High flow kitchen fans can tip the balance

Energy Audit Requirements

- Local exhaust CFM testing vs. estimating.
  - Significant # perform at less than rated level.
    - Actual measurement of the fans best data.
- Building dimensions.
- Number of occupants.
- Blower door test.
  - Infiltration credit (used at the end of the standard weatherization work).

Energy Audit

End-State Planning

- Projecting the air leakage reduction.
- Impact on existing natural draft appliances.
- Plan for the type and location of ventilation.
  - Whole building.
  - Local exhaust mechanical installation.

Energy Audit

End-State Planning

- Design the job via a work plan.
  - Know the depressurization, CFM_{50} numbers when planning work.
  - Assess the impact of planned work.
    - Key juncture sealing.
    - Sidewall insulation.
    - Bypass sealing.
    - Mechanical systems work-water heater, heating system.
  - Project what the final product should be.
  - Installers mock up the fan.
  - Use a good controller and adjust at final test.

On-Site Work Flow

- Sub-contractor (or crew) installs the ventilation prior to the installation of other weatherization measures.
  - Pre-determined that you'll be putting in one or more fans.
  - Prior installation allows for proper air sealing and insulation.

On-site Work Flow

Use Sophisticated Equipment

- More sophisticated equipment allows for:
  - Adjustable flow rates.
    - Intermittent or continuous operation.
    - Controller is as important as the fan.
  - Fan operation is adjusted after the final blower door test.
  - Investment is usually cost-effective.

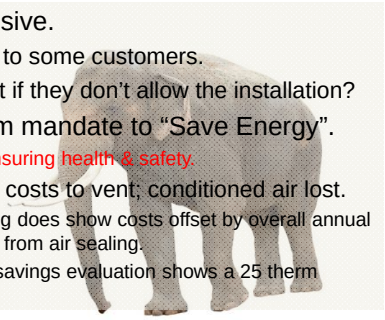
On-site Work Flow

Safety Testing

- Natural draft combustion appliances must draft at the close of work.
  - Daily Tests.
    - When significant changes to the building are completed.
    - Weatherization work can change how the appliance perform.
  - At completion of all weatherization.
    - Part of the final inspection.

Financial Arguments

- Too expensive.
  - Hard sell to some customers.
  - Defer unit if they don't allow the installation?
- Strays from mandate to "Save Energy".
  - While insuring health & safety.
  - Electrical costs to vent; conditioned air lost.
    - Modeling does show costs offset by overall annual savings from air sealing.
    - Therm savings evaluation shows a 25 therm penalty.



The Energy Impact of Ventilation

- Electrical consumption.
  - Adding an electrical draw on the building.
- Heat/Cool energy consumption.
  - Exhausting conditioned air.
- CLIENT perception.
  - This installation is adding to my energy bill.
- Contractor/crew perception.
  - This installation will add to your energy bill.

Energy Impact

Net Effect on Building and Cost

- Costs will vary based on:
  - Heating and Cooling Degree Days.
  - The cost of electricity.
  - Type and cost of heating fuel.
  - Oil is more expensive; natural gas is less expensive.
- Northern state (natural gas):
  - Air Sealing can save $250/year
  - Ventilation costs $75/year to operate
- NET gain of $175 and better air quality.

Fine Tuning: Impact Study

Fine Tuning: WI Refined Whole-Building Requirements

- Bedrooms vs. occupant sizing.
  - Move to occupant based sizing.
    - Study indicated potential for over drying in single person households (Northern climate).
- Established a threshold for whole-building ventilation.
  - Ventilation not required when 62.2 calculation is <15 CFM.
  - Building must have local exhaust.
- Develop customer control package.
  - Guidance for what ventilation is.
  - What has been installed; how to use the equipment;
    - Control options.
  - Measure refusal tied to required signature on liability waiver.

Impact of Ventilation on Weatherized Homes (2011)

- Assessing the IAQ of weatherized homes with 62.2 based ventilation.
  - 32 weatherized homes.
    - Varying tightness and occupancy levels.
  - Remotely controlled ventilation.
    - Turning it on and off.
    - Seasonal Variation.
  - IAQ as measured by.
    - Indoor humidity.
    - CO_2 levels in several locations in the homes.

Ventilation Impact Study

Major Findings

- Humidity.
  - 20% had high indoor humidity without ventilation.
    - Less than 50% did not have high humidity levels
- CO_2 Levels.
  - Less than 50% had high CO_2 levels without ventilation
    - Homes with less than 30 CFM natural/occupant did not.
- 62.2 mostly gets it right.
  - Tight homes and homes with higher occupancy had higher humidity and CO_2 levels.
    - ASHRAE 62.2 good screening tool for need and sizing ventilation based on measured air leakage and occupancy level.

2011 DOE National Training Conference December 12-15, 2011 124

Ventilation Impact Study

Improved IAQ in Most Homes

- Indoor humidity and CO_2 levels both showed statistically significant declines in most cases.
- Reduction tied to ratio of ventilation rates to natural ventilation.

2011 DOE National Training Conference December 12-15, 2011 125

Ventilation Impact Study

Wet Buildings Need Other Solutions

- Does not solve humidity problems with dwellings with heavy moisture load.
  - Still need to deal with source control and targeted local ventilation in problem dwellings.

2011 DOE National Training Conference December 12-15, 2011 126

Ventilation Impact Study

Further Refinement Suggested

- Some homes that didn't have elevated CO_2 or humidity got ventilation (based on 62.2).
  - Suggest limiting installations to homes where estimated natural ventilation rate is less than 30 CFM per occupant.
  - Would further reduce the incidence rate from 5% to 15%.
- All studies available on Wisconsin's Home Energy Plus website under Technical Reports:
  - http://homeenergyplus.wi.gov/section.asp?linkid=122&locid=25

Wisconsin Ventilation Statistics[1]

- Cost & occurrence rate
  - Single family:
    - 62.5%.
    - $504 per unit.
  - 2-4 Unit buildings:
    - 46%.
    - $509 per unit.
  - Mobile homes:
    - 42%.
    - $526 per unit.

[1]Based jobs completed from July 1, 2009-June 30, 2011.